Sudan University of Science and Technology
College of Engineering
B.Sc Of Mechanical Engineering
(Production)

Design, Modelling and Manufacturing The Robotic Arm R21

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October 2017

بسم الله الرحمن الرحيم

المقدمة

إن الحمدلله تعالى, نحمده و نستعينه و نستهديه, و نؤمن به و نتوكل عليه و نعوذ بالله تعالى من شرور أنفسنا و من سيئات أعمالنا, من يهد الله فلا مضل له و من يضلل فلا هادي.

و الصلاة و السلام على المبعوث رحمة للعالمين سيدنا محمد و على آله و صاحبه و أتباعه أجمعين و بعد...

يقول الله تعالى " يَا أَيُّهَا الَّذِينَ آمَنُواْ اتَّقُواْ اللّهَ حَقَّ تُقَاتِهِ وَلاَ تَمُوتُنَّ إِلاَّ وَأَنتُم مُّسْلِمُونَ " {آل عمران ، 102}

ويقول تعالى " يَا أَيُّهَا النَّاسُ اتَّقُواْ رَبَّكُمُ الَّذِي خَلَقَكُم مِّن نَّفْسٍ وَاحِدَةٍ وَخَلَقَ مِنْهَازَوْجَهَا وَبَثَّ مِنْهُمَا رِجَالاً كَثِيرًا وَنِسَاء وَاتَّقُواْ اللّهَ الَّذِي تَسَاءلُونَ بِهِ وَالأَرْحَامَ إِنَّ اللّهَ كَانَ عَلَيْكُمْ رَقِيبًا " {النساء ، 1}

CONTENT

ABSTRACT

This thesis focuses on design, implementation and control of six degrees of (DOF) robotic arm using servo motors to simplify the application of robotic science in CNC (computer numerical control) lap for the students of Sudan university of science and technology. The robot arm designed to work in 0.5 m^2 workspace as an articulated educational robot, loading on the end effector mass of 2 kg. Perspex extruded acrylic sheets were selected as a material for robotic arm. SOLIDWORKS, ANSYS software are used to modelling and analysis the robotic structure, ARDUINO for control the pulses that move the servo motors. The robot arm manufactured and loaded 2 kg with the end effector.

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INTRODUCTION

Chapter One
Introduction

1.1 Introduction

With the growth of technology, the need of new devices grows. Computer and electronic sciences is mostly premier in raising the new technologies. Of course the new technology could affect different engineering fields. For instance, if the robotics and artificial intelligent are considered, it reveals that the technology with high potential, affected many different fields of studies. Therefore, related fields of study could be combined to generate new technologies that can be used in wide fields.

It has become is possible to achieve complex task with the aid of robots and a robust control system. Tasks such as industrial applications, medical operations and emergency situations requires precision, speed, low response time and certainty, this is where the need for human assisting equipment is the most.

The robots play important roles in daily lives and are able to perform the tasks which can’t be done by humans in terms of speed, accuracy and difficulty. Robots can be employed to imitate human behaviours and then apply these behaviours to the skills that lead the robot to achieve a certain task. They don’t get tired or face the commands emotionally, and since they are designed by humans. They can be programmed and expected to obey and perform some specific tasks.

The idea of robotic is to create practical and useful robots that facilitate the daily tasks. Because of the independency of the robots, they have longer life time comparing with the humans and can be helpful in industry, dangerous tasks and nursing homes.

Recently, robots operate in almost human labours mostly in the fields which are unhealthy or impractical for workers.

There are situations where a robot is replacement for human because the human does not have the capability to work under the specific conditions, such as working in the space and under the water. Therefore, while designing a robot, considering the factors such as concept and techniques, artificial intelligence and cognitive science are essential in order to obtain an effective deign. The other situation is when the robot is used to ease the actions done by the human.

Obviously, building a robotic arm is not a new idea, but still the design and the specifications can differ from other designs. For instance, the circuitry, degree of freedom (DOF), algorithm, program, attachments, equipment, accuracy and speed, completely depend on the designer's tact.

The challenge is to be able to perform some physical tasks close to a human's hand actions, such as replacement and grabbing, under the conditions where a human hand is not a particular solution.

1.2 problem statement

The Problem is the Lack of robotic application in Sudan University of Science and Technology especially in the CNC lab. Since the CNC is a modern technology therefore a decision was made to make the handling process on the same level of technology. So, building a robotic arm to work as a handler will give the students a taste of the importance of technology and how it can make life a lot easier and it will continue for the generations to come.

1.3 Project objective

Designing Modelling and Manufacturing a robot arm for handling processes in CNC lab and it can be used as an educational model.

1.4 Project scope

Design and fabricate a unit of articulated handling robot with 0.5m2 workspace as a functional robotic arm using SOLIDWORKS software in modeling and static analysis, Perspex acrylic sheets as a material, and manufacturing process via laser cutting machine, to work in the CNC lab at SUST.

1.5 project layout

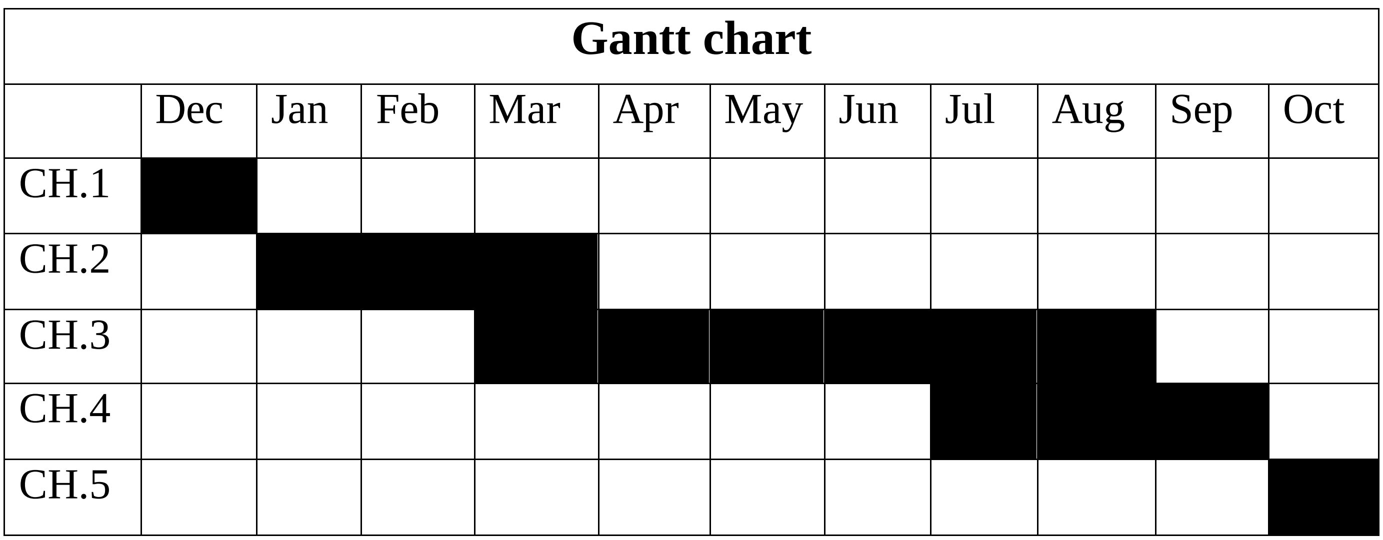


Figure 1.1 project layout (Gantt chart 2016-2017)

CHAPTER TWO

THEORETICAL BACKGROUND & PREVIOUS STUDIES

Theoretical Background & Previous Studies

2.1 Background

Generally, robots are designed, built and controlled via a computer or a controlling device which uses a specific program or algorithm. Programs and robots are designed in a way that when the program changes, the behavior of the robot changes accordingly resulting in a very flexible task achieving robot. Robots are categorized by their generation, intelligence, structure, capabilities, application and operational capabilities. In this study robots are reviewed according to their structural properties.

2.2 Structural classifications of robots

i. Cartesian Robots.
ii. Cylindrical Robots.
iii. Spherical Robots.
iv. SCARA Robots.
v. Articulated Robots.

2.2.1 Cartesian Robots

Cartesian robots are used for pick and place work, application of sealant, assembly, operations, handling machine tools and arc welding. It's a robot whose arm has three prismatic joints, whose axes are coincidental with the Cartesian coordinators.

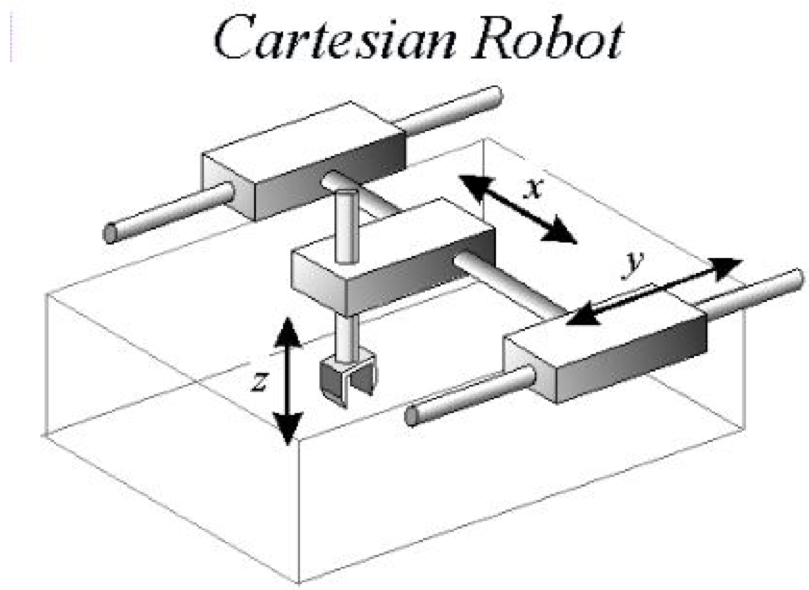


Figure 2.1 Cartesian Robot

2.2.1.1 Application of Cartesian Robot

i. Applying Adhesive:

This robot is being used to apply adhesive to a pane of glass. This robot is capable of handling large sized work pieces.

ii. Pallet transfer:

This orientation of a Cartesian robot transfers Integrated Circuits (ICs) from a pallet and transfers the part to a specific place.

iii. Product inspection:

Companies need to monitor their products to ensure that they are of a high quality. Cameras mounted on the Cartesian robot above monitor the passing components for inaccuracy. Due to its construction the robot can move along with the moving conveyor and focus on a product at once.

iv. Transfer and stacking:

Owing to its linear movement the Cartesian robot is ideal for the transfer and stacking of sheet metal or timber sheets. It can feed sheets into processing machines or draw them away as finished products.

Advantages

i. Large workspace.
ii. High speed and stiffness.
iii. Good performance.
iv. Good for multiple machines and lines.
v. Good handling with large loads.

Disadvantages

i. Large structural frame.
ii. Complex mechanical properties for linear sliding movement.
iii. Energy inefficiency.
iv. Large floor space requirement.
v. Limited workspace.
vi. Common workspace restriction.

2.2.2 Cylindrical Robots

Cylindrical robots are used in assembly operations, handling of machine tools, spot welding and handling at die cast machines. They also have many uses in medical testing. The example below has two prismatic joints and one rotary joint. A Cylindrical robot is able to rotate along its main axes forming a cylindrical shape.

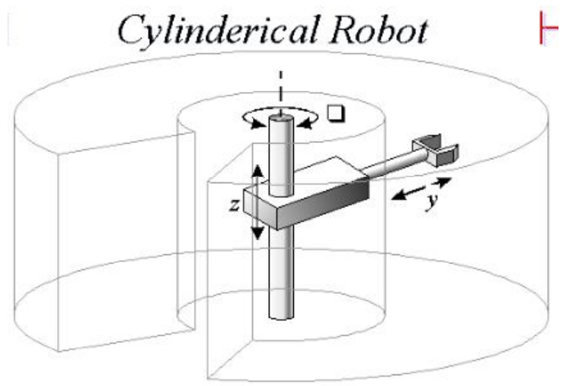


Figure 2.2 Cylindrical Robot

2.2.2.1 Application of the Cylindrical Robot

The medical robot is used in numerous medical applications, for DNA screening, forensic science, drug development and toxicology. These robots are suitable in medical research where hundreds of samples must be tested and the same repetitive tasks performed many times. The robot eliminates human error providing more repeatable yields and consistent results. A typical example of its duties would be to pull out a drawer to access a test plates, lift out a sample plate, close the drawer and finally take the sample to another instrument to be tested.

Advantages

i. No collisions while moving.
ii. Two linear axis results in simpler movement.

Disadvantages

i. Large structural frame.
ii. Incompatible with other robots.
iii. Inaccurate on the end resolution compared to Cartesian robot.

2.2.3 Spherical Robots

Spherical or Polar Robots combine rotational movements with single linear movements of the arm. The polar robot is sometimes referred to as the gun turret configuration. They are generally used in many welding applications mainly spot, gas and arc. Polar robots are extremely suitable for reaching into horizontal or inclined tunnels.

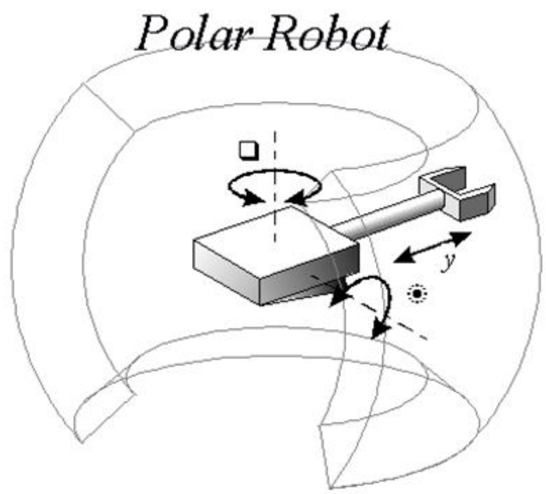


Figure 2.3 Polar Robot

2.2.3.1 Applications of Spherical Robot

The main application for these types of robots is welding. They can be quite large and weigh over a 1000kg. Polar Robots are used widely in the car manufacturing industry.

Advantages

i. Light weight.
ii. Simple kinematics.
iii. Compatible with other robots especially with ones in a common workspace.
iv. Sharp joints level.
v. Good resolution due to perpendicular of the end-efforts' errors.

Disadvantages

i. Need of variable torque due to the large size.
ii. Challenging counter balancing.
iii. Chance of having collision with obstacles due to bounded ability to avoid collisions.
iv. Large position errors due to the rotation and proportional radius.

2.2.4 SCARA Robots

This configuration was developed to meet the needs of modern assembly work where fast movement with light payloads is required. The rapid placement of electronic components on PCB's is an obvious application. The SCARA robot is a combination of two horizontal rotational axes and one linear that moves vertically.

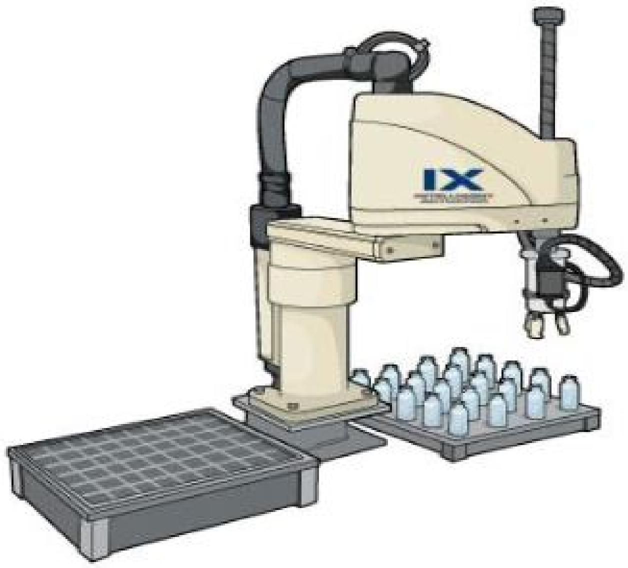


Figure 2.4 SCARA Robot

2.2.4.1 Applications of a SCARA Robot

i. Testing a finished product:

The SCARA robot is testing a newly made calculator to ensure it is operational prior to packaging. The camera observes the screen to see if the operation performed by the robot is achieving the desired result.

ii. Stacking lightweight component:

The SCARA design can quickly remove components from an assembly line and accurately stack them.

iii. Part assembly:

The SCARA robot is excellent for precision positioning and makes it very suitable for the assembly of components. The picture above shows the robot taking parts from the supply unit and assembling them. The robot can pivot around to the left and change its gripping hand to a screw or drilling head. These different heads for the robot are known as end effectors.

iv. Multi-function:

Here the SCARA can be seen transferring the component from the assembly stage to the testing stage. Once the component has passed the quality check the robot arm will place it on the conveyor belt to be transferred to the next stage.

2.3 Kinematics of Robots

Kinematics is the most basic study of how mechanical systems behave. In mobile robotics, understanding the mechanical behaviour of the robot is needed in order to design appropriate mobile robots for tasks and to understand how to create control software for an instance of mobile robot hardware, the process of understanding the motions of a robot begins with the process of describing the contribution each motor provides for motion, there are additional degrees of freedom and flexibility due to the wheel axles, wheel steering joints, and wheel castor joints. In defining the workspace of a robot, it’s useful to first examine its admissible velocity space. Given the kinematic constrains of the robot, its velocity space describes the independent components of robot motion that the robot can control. The number of dimensions in the velocity space of a robot is the number of independently achievable velocities. This is also called the differentiable degree of freedom (DDOF), A robot’s is always equal to its degree of mobility. The objectives of kinematic controller is to follow a trajectory described by its position or velocity profile as a function of time. The control problem is to recomputed a smooth trajectory based on line and circle segments which drives the robot from the initial position to the final position. Feedback control: A more appropriate approach in motion control of a mobile robot is to use a real-state feedback controller. With such a controller, the robot's path-planning task is reduced to setting intermediate positions (sub-goals) lying on the requested path.

2.4 Types of Electric Motors

Actuators:

Motors are the most common way to control the movements of robots and are known as actuators. They can be connected to gears and wheels and are a perfect way of adding mobility. There are a number of different types of motors that can be used, DC, Stepper and Servo motors.

2.4.1 DC Motors:

These are the most common motors available, connected to a power supply by two wires. The direction of a DC motor can be changed by reversing the polarity of the motor supply voltage. DC motors draw a large amount of current and as a result cannot be wired straight from a control system such as PIC. DC motors do not offer accurate, controlled rotation.

Figure 2.5 DC Motor

2.4.2 AC motors:

AC motors are commonly found in industrial factories driving conveyor belts or other heavy machinery. There are very few robot arms that use AC motors. Some of the reasons are due to poor accuracy, low starting torque and poor dynamic response.

Figure 2.6 AC Motor

2.4.3 Stepper Motors:

Stepper motors work in a similar way to dc motors, however where a dc motor has just one electromagnet, the stepper has many. The stepper is controlled by the sequential turning on and off of these coils. Each time a new coil is energized the motor rotates another couple of degrees. The number of degrees that a motor turns with each pulse is called the step angle. Repeating the sequence causes it to move a few more degrees, this continues until a full rotation is achieved.

Figure 2.7 Stepper Motor

2.4.4 Servo Motors:

The servo motor offers the smoothest and greatest control. They can be told to rotate to a specific point, making them ideal for applications that require precise movement. The rotation of a servo is limited; most rotate from 90° to 180° though some can complete a full rotation. They cannot rotate continually due to their structure so are unsuitable for driving wheels, but their torque and control make them suitable for powering robotic arms and such.

Figure 2.8 Servo Motor

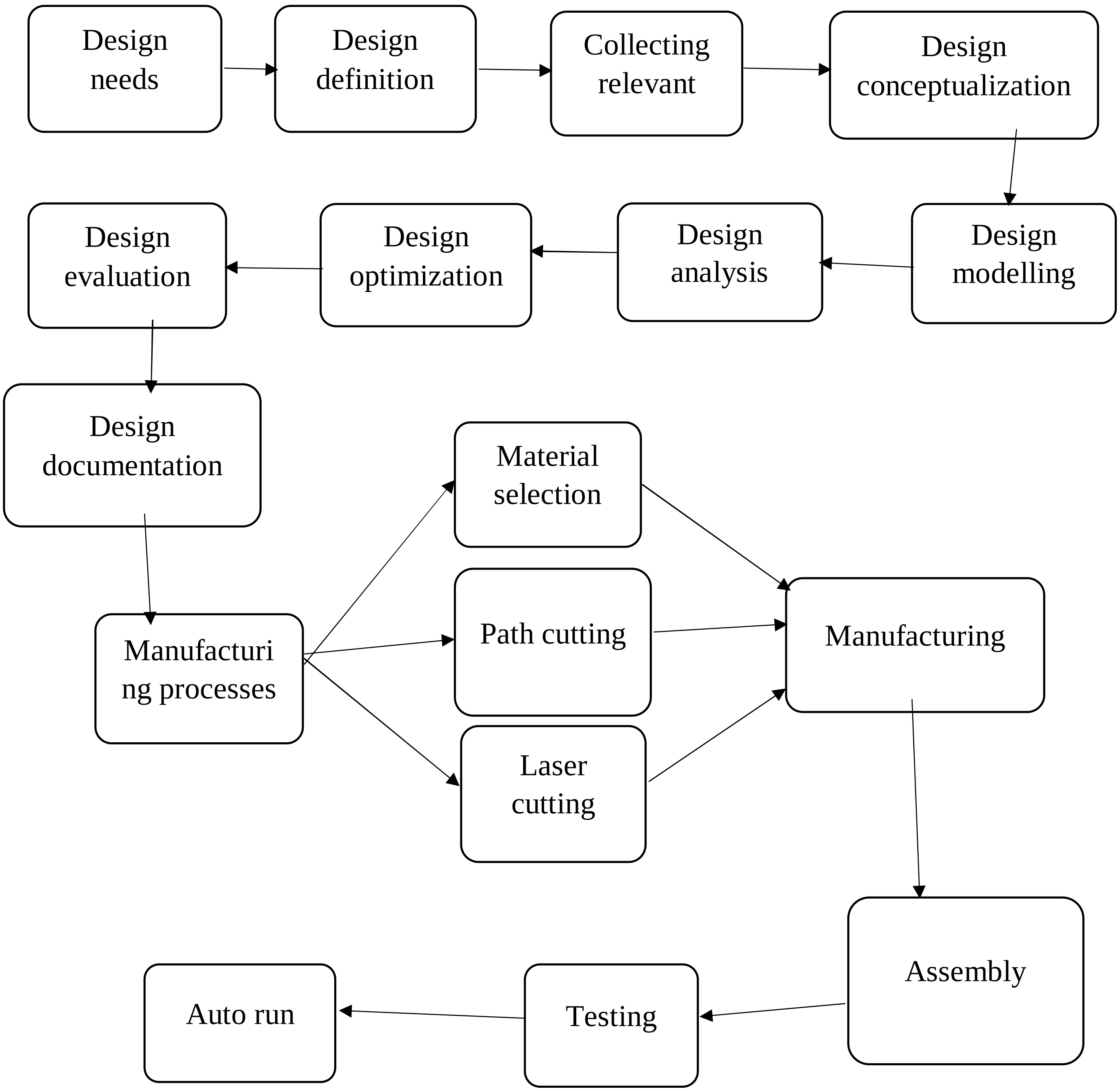
CHAPTER THREE

METHODOLOGY

Chapter Three

Methodology

3.1 Methodology Flow



3.2 Assumption of Building the Kinematic Structure

The dimension and workspace configuration of the structure is to move freely in 0.3 meter. The specifications of each actuator are determined to carry out the rotary operations. The structure of the robot is built with Perspex acrylic sheets in order to decrease the overall weight of the robot. The Perspex acrylic sheets are also strong enough to keep and hold the whole parts tightly together. The arm is attached to a base which is the most bottom part of the robot. It is important to mention that the base ought to have considerably heavy weight in order to maintain the general balance of the robot in case of grabbing an object.

Although the idea of using stepper and gear motors is brilliant, but physical movement of the robot is done by using servo motors. The advantage of the servo is that they can be programmed to return to their initial position. Since the servo motors operate using the signals received from the microcontroller, they could be programmed according to the requirements. However, this characteristic of the servo motors is actually a disadvantage, because the chance of sending and receiving a wrong signal is high which causes the servo to operate incorrectly.

The developed robot in this study is a stationary articulated robotic arm with 4 DOF with only revolute joints which includes base, shoulder, elbow, gripper roll, gripper pitch and gripper spin.

All parts of the robot including the parts for shoulder, elbow, gripper and etc., where been manufactured accurately by laser cutting machines to avoid labour error. The gripper of the arm is designed in a way which uses a single actuator and follows a basic physical gear concept. This means that when the mini servo actuates, it turns the gear which is attached to it causing the gripper to expand and contract.

3.3 Mathematical Model of the Kinematics

Each robot design involves mathematical modelling of the kinematics, structure design, electronic design and software design. The robotic arm has a total of four axes. Three major axis which correspond to the base, shoulder and elbow are needed to move the arm to the desired spot, and one minor axis which correspond to the gripper pitch. The design has four rotary joints.

3.4 Material selection

Perspex acrylic sheets are one of the most used materials for its broad application potential. The robot hand is made from Perspex extruded acrylic sheets. The main advantage of extruded sheet is accuracy in thickness and lower price. All sheets have UV protection and they are resistant to weather conditions.

3.5 Robot controller

Robot arm can be control via a mouse, and build using Arduino and processing libraries. To control the robot arm, mouse can send a byte value over the serial port and then read that in the Arduino code. Depending upon the value sent different motors will be activated. For the processing sketch made a few buttons for each motor and also coded the use of the keyboard for another control method. Using either arbitrarily moves the arms motors. Sketches are the basis for all the further work as well as testing the arm, from this move to inverse kinematics as well as programming repeat actions for the arm to perform.

3.5.1 Robotic Arm Software

Robot software is the set of coded command or instructions that tell a mechanical device and electronic system, known together as robot, what tasks to perform. Robot software is used to perform autonomous tasks. Many software systems and frameworks have been proposed to make programming robots easier.

Some robot software aims at developing intelligent mechanical devices. Common tasks include feedback loops, control, path finding, data filtering, and locating.

3.5.1.1 Processing program (IDE)

Processing is an open source language development tool for writing programs in other computers. Useful when you want those other computers to "talk" with an Arduino, for instance to display or save some data collected by the Arduino. You can use the serial monitor of the Arduino software (IDE) to view the sent data, or it can be read by processing, processing consists of:

i. The processing development environment (PDE). This is the software that runs when you double-click the processing icon. The PDE is an integrated development environment (IDE) with minimalist set of features designed as a simple introduction to programming or for testing one-off ideas.
ii. A collection of functions (also referred to as commands or methods) that make up the "core" programming interface, or API, as well a several libraries that support more advanced features such as sending data over a network, reading live image from a webcam, and saving complex imagery in PDF format.
iii. A language syntax, identical to java but with a few modifications.
iv. An active online community.

Whilst both sketches visually look different they use pretty much the same methods. The main thing is that for each point, shape or item wish to click and drag rely on detecting where the mouse is, if it is being clicked and if dragging the mouse. Can use processing inbuilt functions mouse pressed () and mouse dragged () but still need to write conditional statements depending on where the mouse is. To do this we can get the X and Y co-ordinates of the mouse using mouse using mouse X and mouse Y and to compare these values we need to store the X and Y co-ordinates of any shape as variables – the easiest way is to use the P vector variable type which in its simplest use is as array that stores an X and Y value. Now we can mathematically compare the values and limit the movement of our shapes only moving when the mouse is in the correct area.

When getting the X and Y values from the mouse position we need to make sure these are converted to integers, for which we first use the round () method to convert our float to 1 decimal place and then use the int() method to case the value as an integer. We also need integer values as it makes it much easier to send ints over the serial port as the libraries allow for these values. The rest of the processing code is fairly straight forward we use text (), rest(), ellipse(), line(), fill() and stroke() functions to create our visualization. The only other thing to note is that in draw () method we always write the values to the serial port.

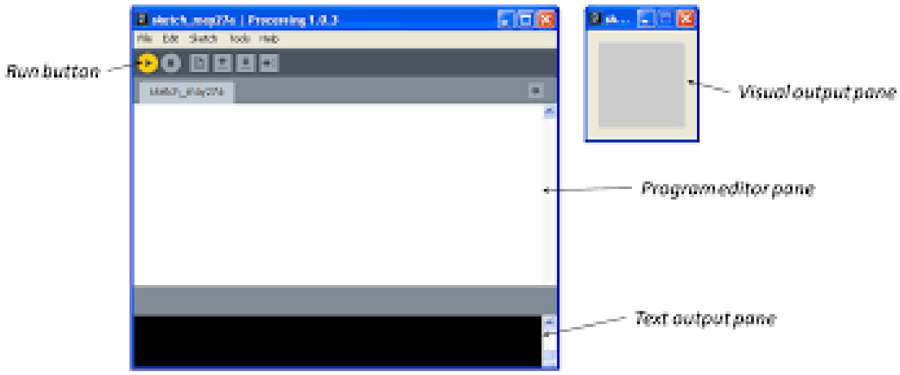


Figure 3.1 processing program (IDE)

3.5.1.2 Standard Firmata library

Firmata is a generic protocol for communicating with microcontrollers from software on a host computer. It is intended to work with any host computer software package. This library allows you to control an Arduino board from processing without writing code for the Arduino. Instead, you upload a standard firmware (program) to the board and communicate with it using the library. The firmware is called firmata, and is included in the Arduino software. The corresponding processing library can be downloaded below.

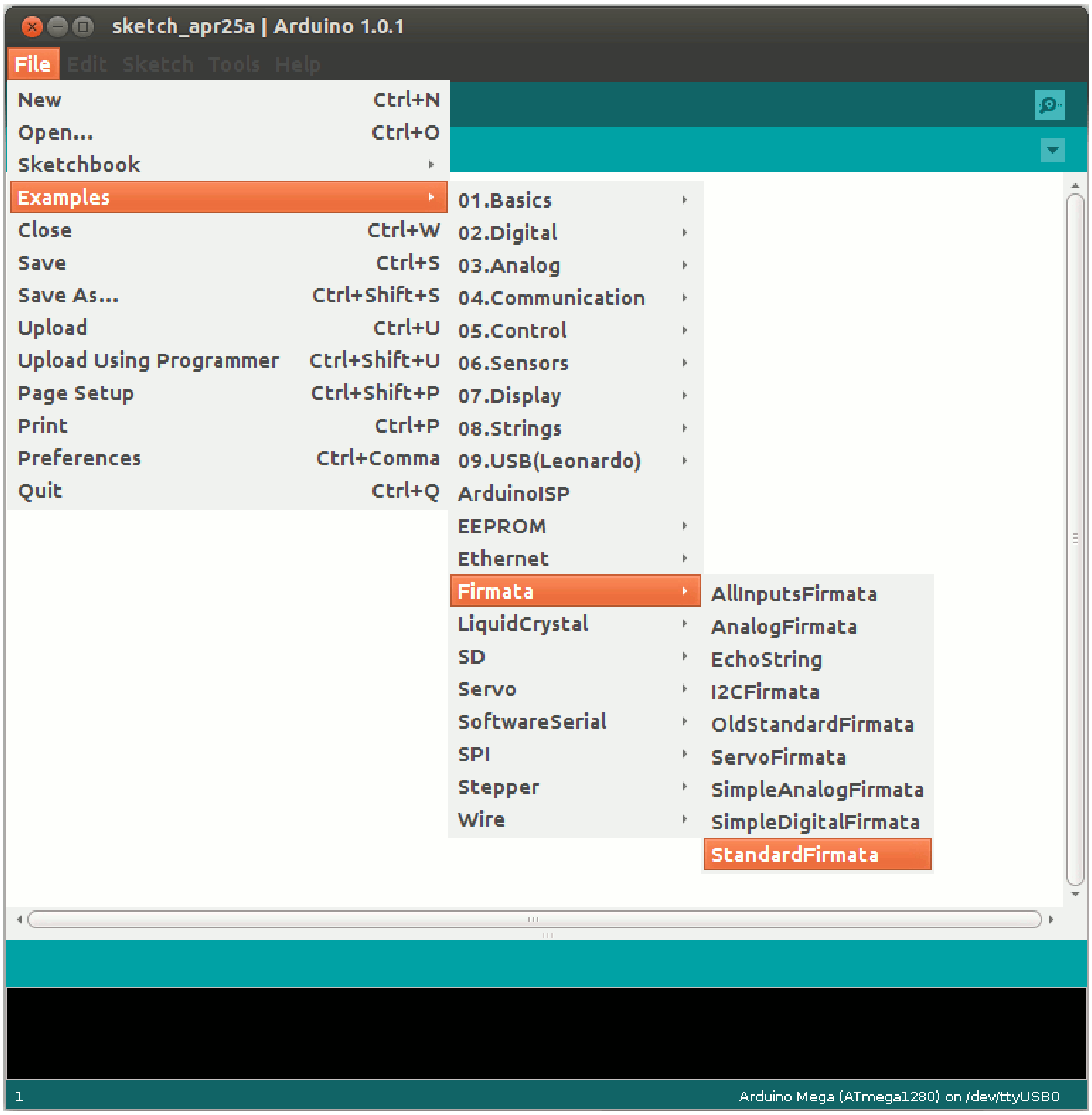


Figure 3.2 Standard Firmata library

3.5.2 Robotic Arm hardware

The kits also come with common robotic hardware that connects easily with the software (infrared sensors, motors, microcontroller board, microphone and video camera).

3.5.2.1 servo motor (MG996R High torque)

This high torque MG996R digital servo features metal gearing resulting in extra high 10Kg stalling torque in a tiny package. The MG996R is essentially an upgraded version of the famous MG996R servo, and features upgraded shock proofing and a redesigned PCB and IC control system that make it much more accurate than its predecessor. The gearing and motor have also been upgraded to improve dead bandwidth and cantering. The unit comes complete with 30cm wire and 3 pin female header connectors that fit most receivers, including Futaba, JR, GWS, Cirrus, Blue bird, Blue arrow, Corona, Berg, spectrum and Hitch. This high torque standard servo can rotate approximately 120 degrees (60 in each direction). The MG996R metal gear servo also comes with a selection of arms and hardware to get you set up nice and fast.

Specifications of servo motors:

i. Weight 55g
ii. Dimension 40.7*10.7*42.9 mm approx.
iii. Stall torque 9.4 kgf.cm (4.8V), 11 kgf.cm (6V) (need this torque because calculate torque and load in different joint of arm used equation standard).
iv. Operating speed 0.17s/60° (4.8V), 0.14 s/60° (6V)
v. Operating voltage 4.8V and 7.2V
vi. Running current 500 – 900 mA (6V)
vii. Stall current 2.5 A (6V)
viii. Dead bandwidth 5 µs
ix. Stable and shock proof double ball bearing design
x. Temperature range 0-55 °C [4]

Figure 3.3 high Torque MG996R

3.5.2.2 Arduino Board (Mega 2560)

The Arduino mega 2560 is a microcontroller board based on the AT mega 2560. It has 54 digital input/output pins (of which 14 can be used as PWM output), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillators, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. Power of the Arduino mega can be powered via the USB connection or with an external power supply. The power source is selected automatically. Need high response form PC to microcontroller and microcontroller can be send fast to motors.

Specifications of Arduino board

i. Microcontroller AT mega2560
ii. Operating voltage 5V
iii. Input voltage (recommended) 7-12V
iv. Input voltage (limits) 6-20V
v. Digital I/O pins 54 (of which 14provide PWM output)
vi. Analog input pins 16
vii. DC current per I/O pin 40 mA
viii. DC current per 3.3V pin 50 mA
ix. Flash memory 256 KB of which 8 KB used by boot loader
x. SRAM 8 KB
xi. EEPROM 4 KB
xii. Clock speed 16 MHz[5]

Figure 3.4 The Arduino Mega 2560

3.5.2.3 LM 7806 Regulators

The 7806 three-terminal positive voltage regulator is available in the TO-220/D-PAK package making them useful in a wide range of applications. 7806 employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If proper heat sinking is provided, it can deliver over 1A output current. Motors need 6 voltages because selected this regulator.

Specifications:

i. Input voltage 10V
ii. Operating temperature -40-to-125 °C
iii. Output current 500 mA
iv. Output voltage Min (5.75V), Typ.(6V), Max.(6.25V) [6]

Figure 3.5 LM 7806 regulator

3.5.2.4 IR sensor (TCRT5000)

The TCRT5000 is reflective sensor which includes an infrared emitter and phototransistor in a lead package which blocks visible light. The package includes two mounting clips. TCRT5000L is the long lead version.

Specification:

i. Package type leaded
ii. Detector type phototransistor
iii. Dimensions (L*W*H in mm) 10.2* 5.8*7
iv. Peak operating distance 2.5 mm
v. Operating range within >20% relative collector current: 0.2mm to 15mm
vi. Typical output current under test: IC =1mA
vii. Daylight blocking filter
viii. Emitter wavelength 950 nm
ix. Lead (Pb) free soldering released
x. Compliant to RoHS directive 2002/95/EC and in accordance to WEEE 200/96/EC [7]

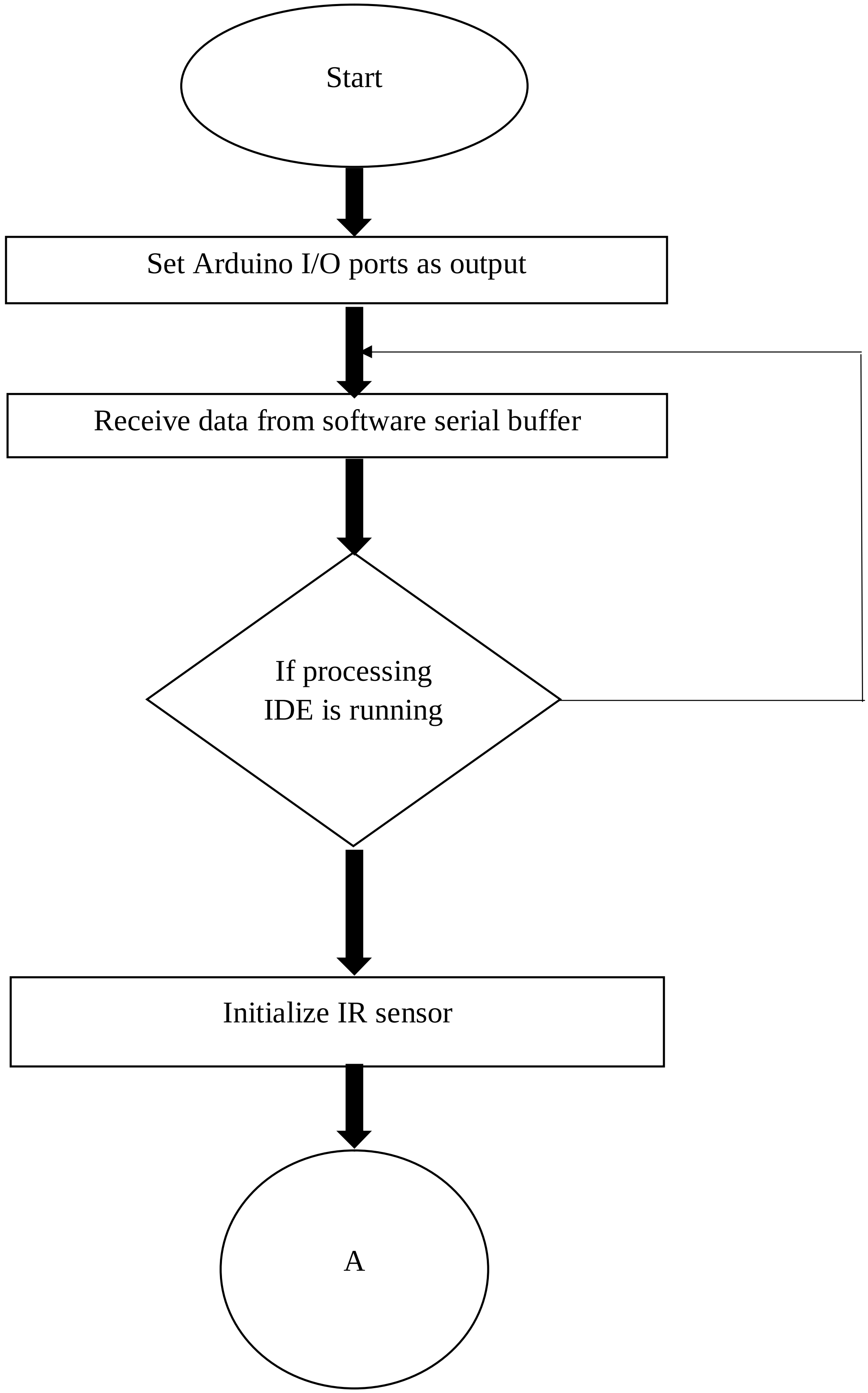
Figure 3.6 TCRT 5000 sensor

3.6 Circuit Design

The robot arm consists of six servo motors which controlled by mouse which passes data of mouse position and vectors to Arduino board via serial port over firmata protocol, most of the computation is done on the computer side through processing IDE which is java based development environment for interactive projects and applications, the robot arm motion can be recorded and stored into a file which can be replayed.

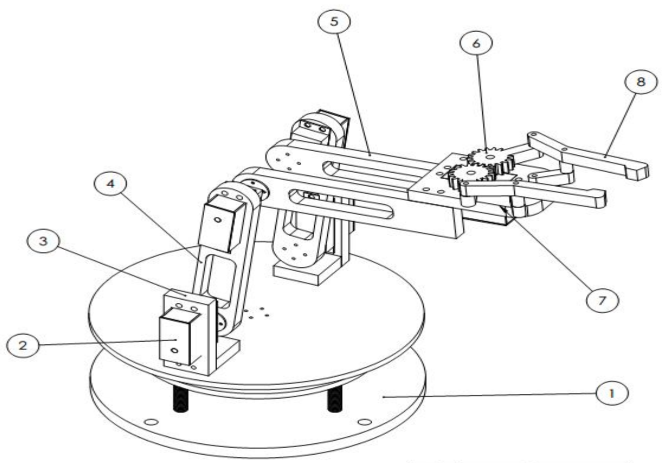
3.7 operation

At the system power, which is initialized by running the processing code, the Arduino start the configuration of I/O ports according to signals received from the serial port buffer, the processing IDE proceeds to initialize the mouse controller and start reading data if sensor detected object, these data contains vector and coordination data such as X, Y and Z position of mouse, these data are then processed and fed into corresponding servo motors connected to the Arduino board.


Start
Set Arduino I/O ports as output
Receive data from software serial buffer
If processing IDE is running
Initialize IR sensor
A

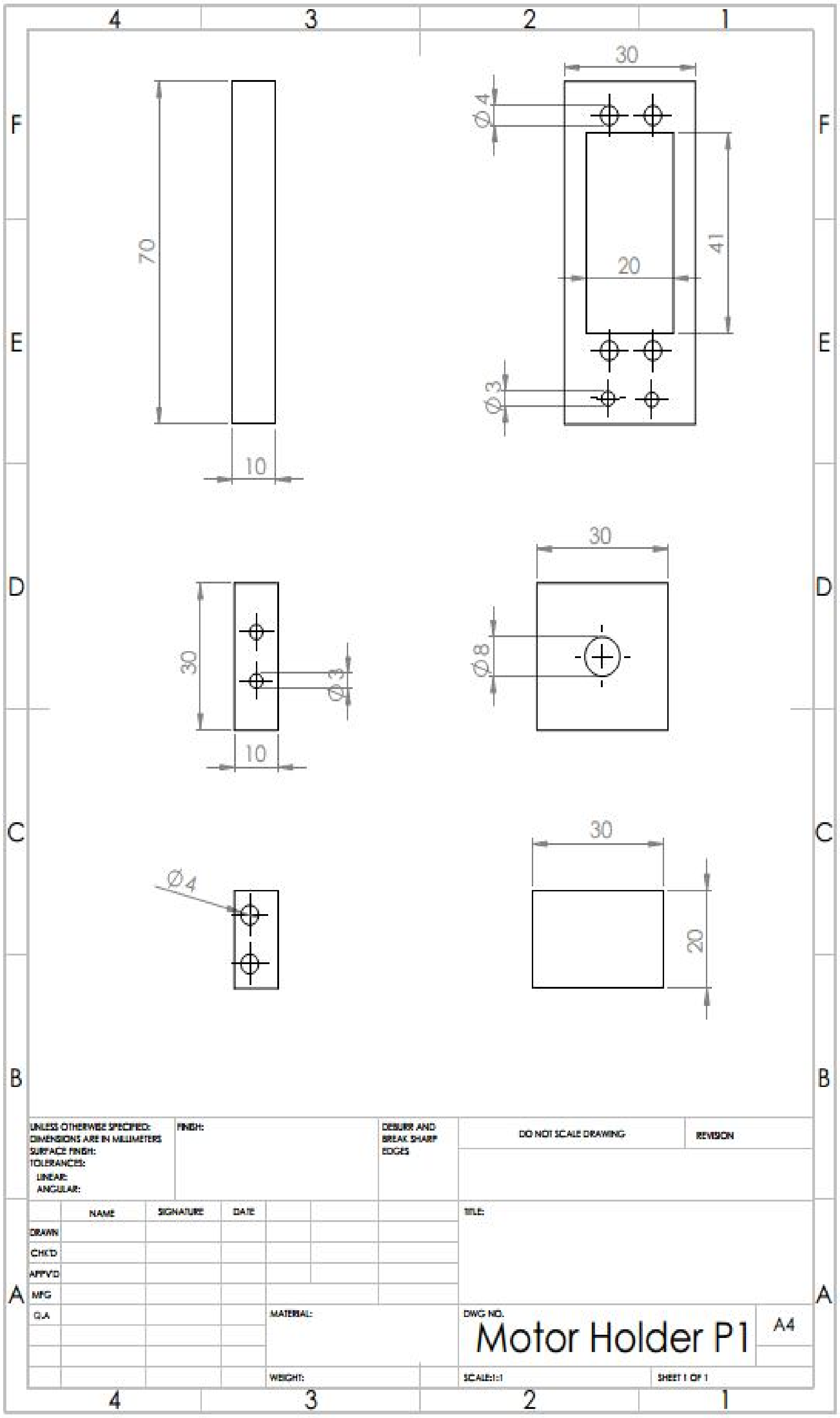
3.8 Design

After considering all the requirement of workspace area 0.5 m², Perspex acrylic extruded sheets, the needed torque from servo motors, the mass of 2 kg loaded on the gripper, the robot had been designed via SOLIDWORKS and analysed via ANSYS software. The details of drawings shown in appendix.

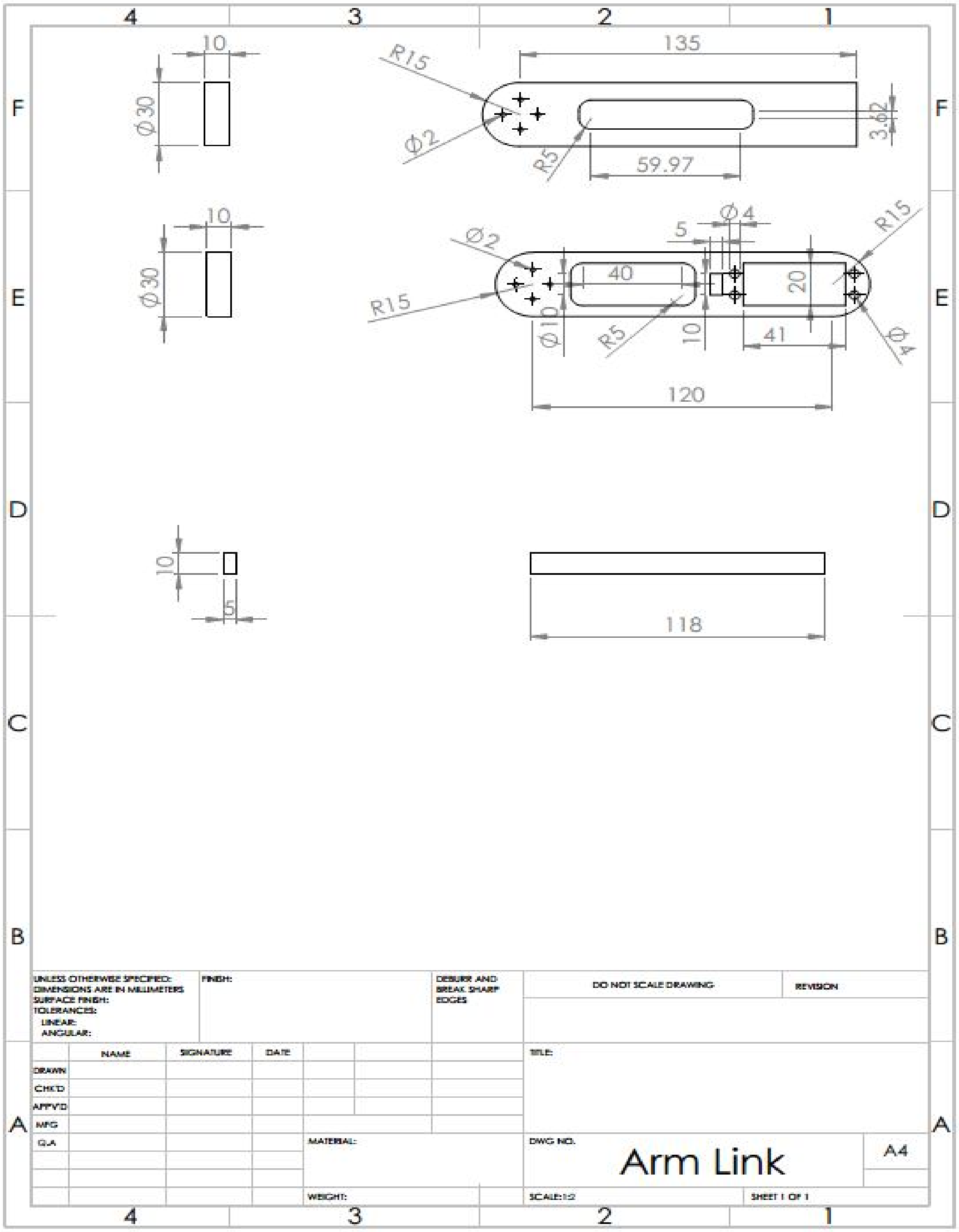


1	Base
2	Servo Motor
3	Motor Holder
4	Sholder Link
5	Arm Link
6	Gear
7	Gripper Support
8	Gripper

Details of drawings



Motor holder



10
Ø30
R15
135
Ø2
R5
59.97
3.62
5
Ø4
40
20
10
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41
120
118
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
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Arm Link
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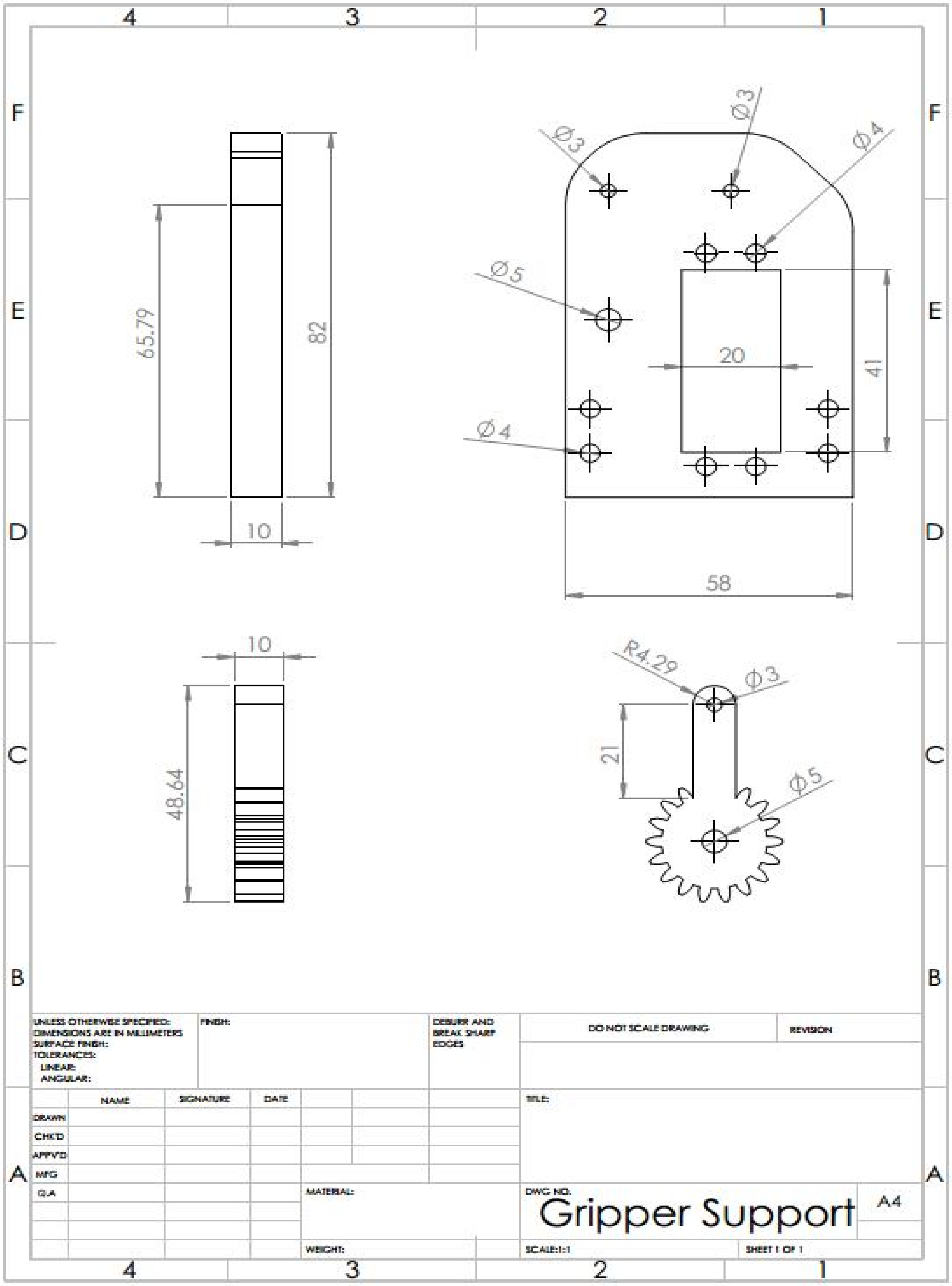
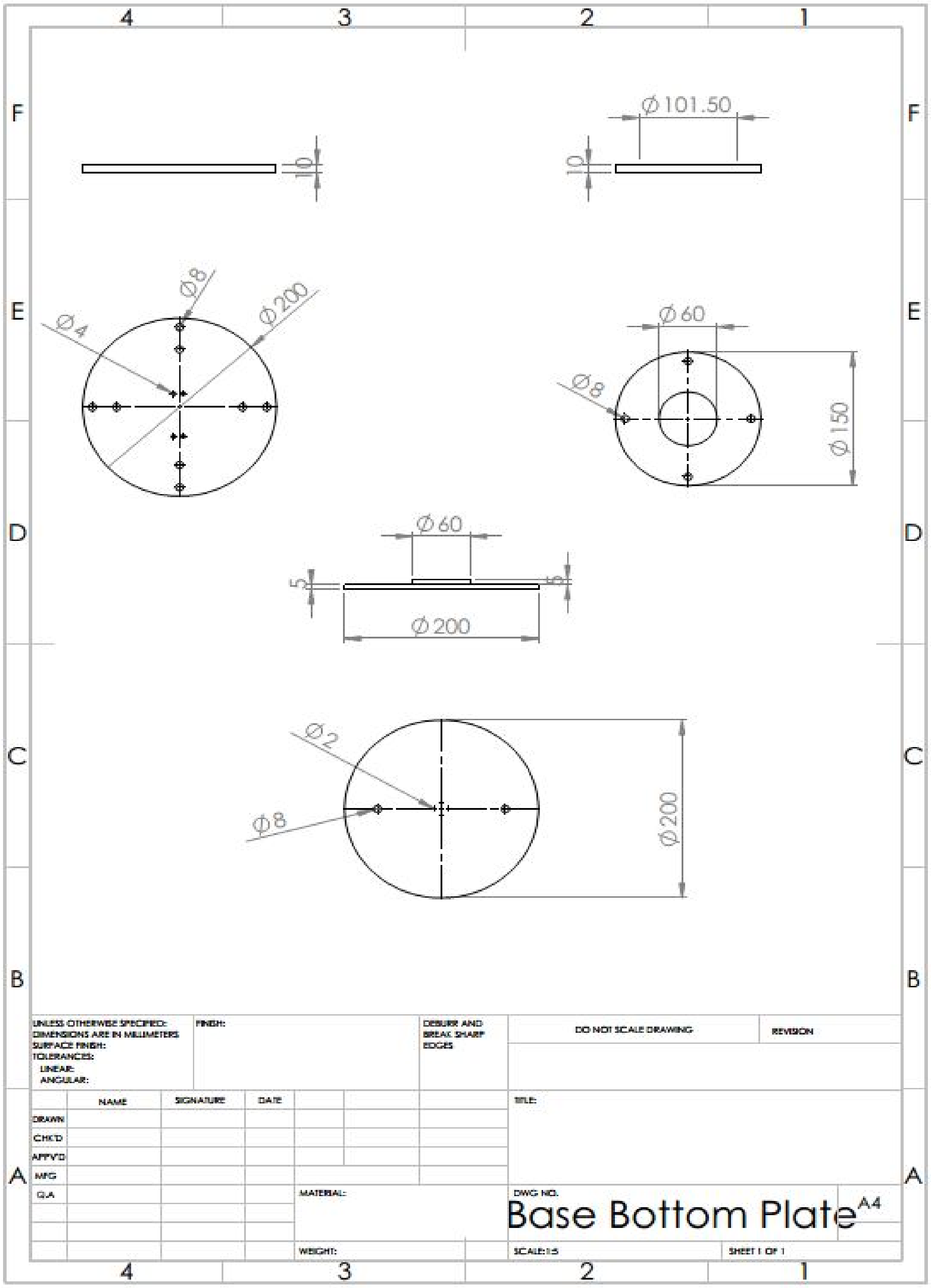
WEIGHT:
SCALE:1:2
SHEET 1 OF 1

Links



Gripper Support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Base Bottom Plate
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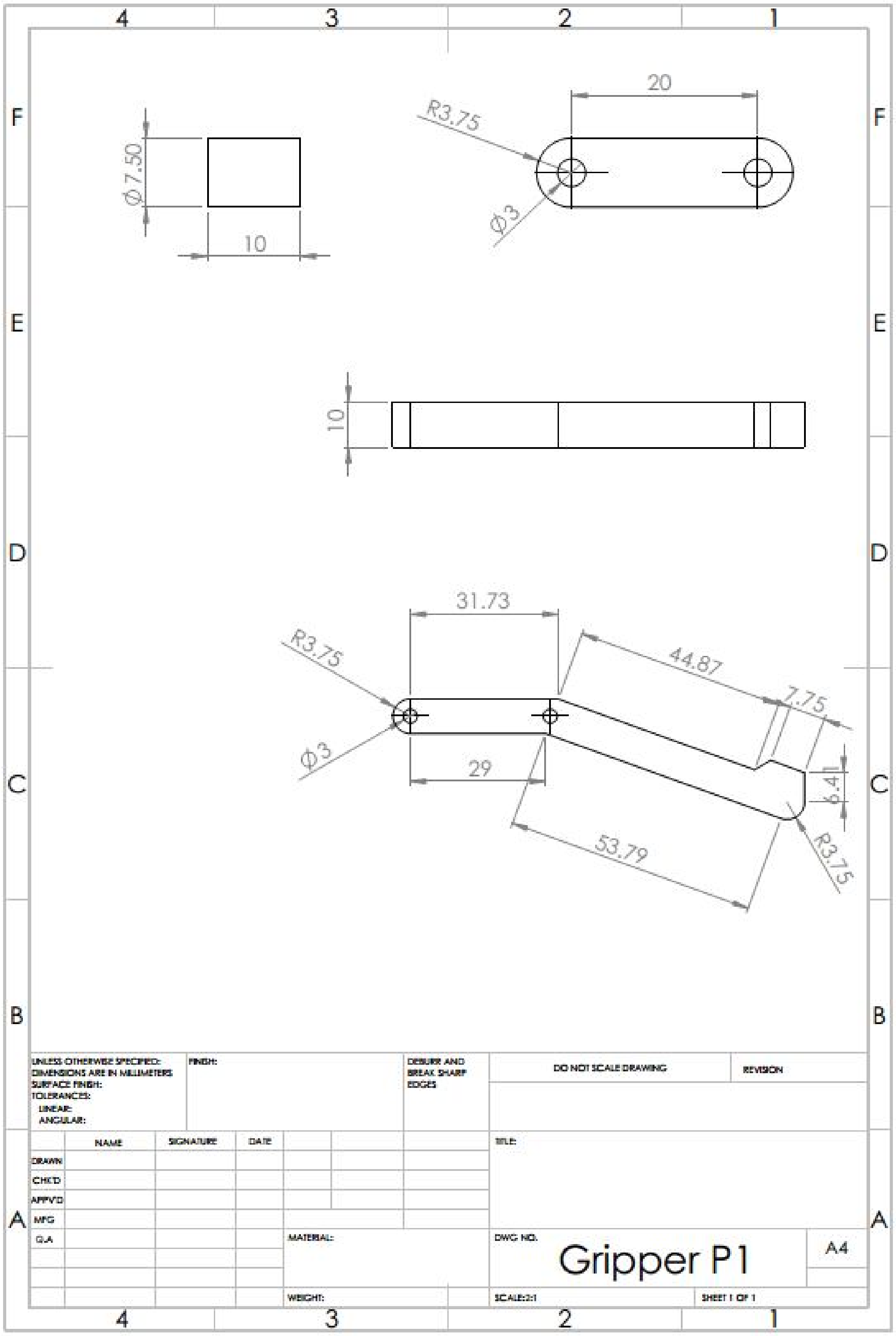
SHEET 1 OF 1

Bases



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Gripper P1
A4
WEIGHT:
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SHEET 1 OF 1

Gripper P1

3.9 manufacturing process

Laser cutting is a technology that uses a laser to cut materials, and is typically used for industrial manufacturing applications, but is also staring to be used by schools, small businesses, and hobbyist. Laser cutting work by directing the output of a high-power laser most commonly through optics. The laser optics and CNC (Computer numerical control) are used to direct the material or the laser beam generated. A typical commercial laser for cutting material would involve a motion control system to follow a CNC or G-code of the pattern to be cut onto the material. The focused laser beam is directed at the material, which then either melt, burns, vaporizes away, or is blown away by a jet of gas, leaving an edge with a high-quality surface finish. Industrial laser cutters are used to cut flat-sheet material as well as structural and piping materials.

figure 3.7 Laser cutting machine

CHAPTER FOUR
RESULTS AND DISCUSSION

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Mesh (moderate mesh)

Meshing is the process used to fill the solid model with nodes and elements to Create finite element analysis model (FEA) model.

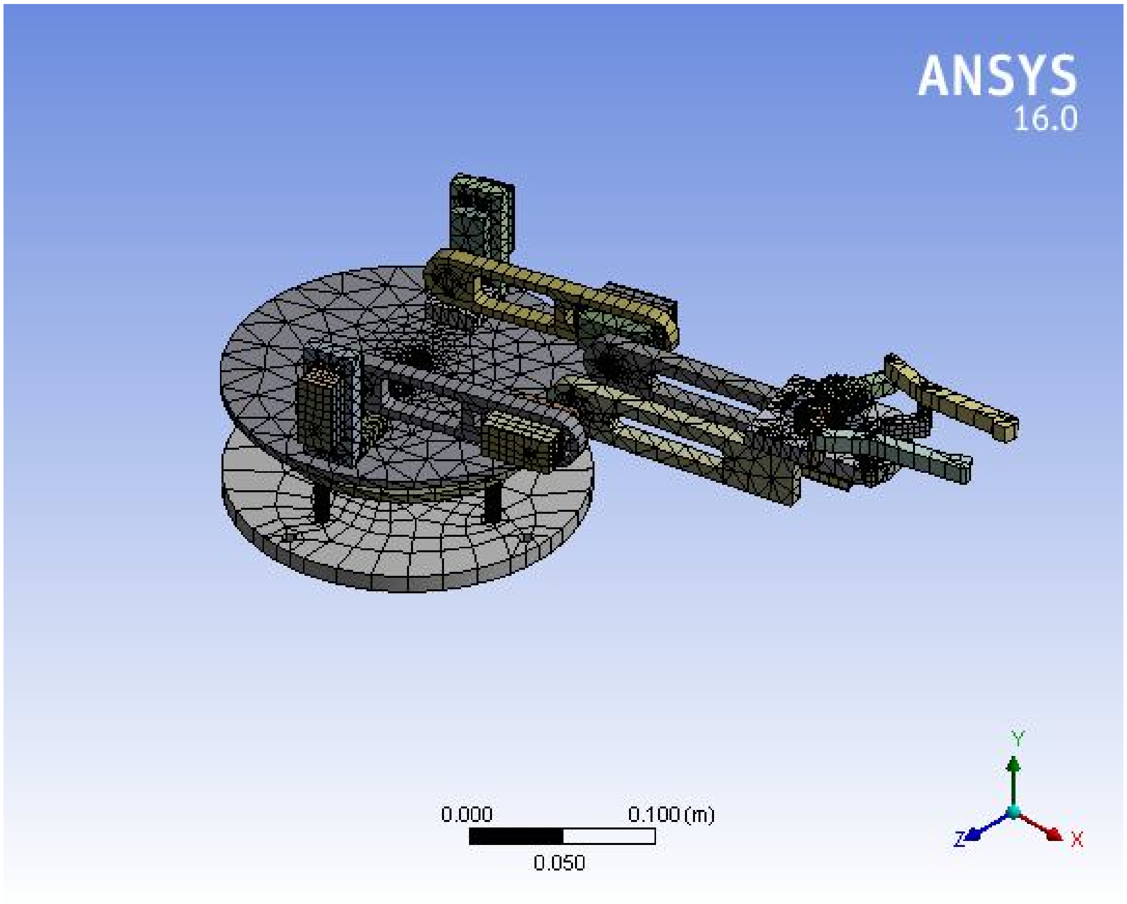

Figure 4.1 Mesh

4.2 Simulation results

The analysis was made to get the maximum and the minimum of

(yield stress of acrylic sheet equal to 75MPa)

i. the total deformation.

ii. the stress.

iii. the strain.

4.2.1 Total Deformation

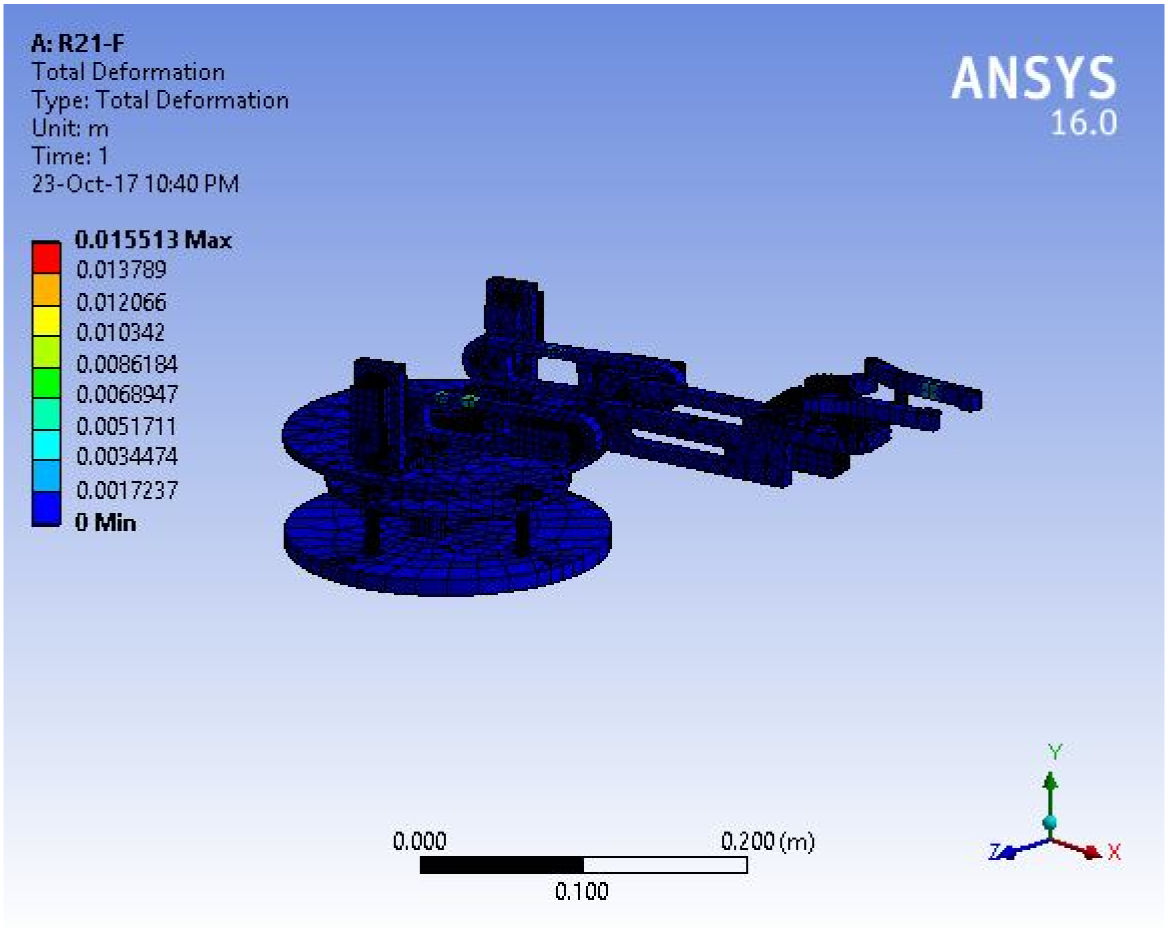

Figure 4.2 Total deformation

The maximum deformation pointed in the 2Kg load and it decrease Toward the robot base. Because the mass loaded by the end effector.

4.2.2 Maximum principle stress

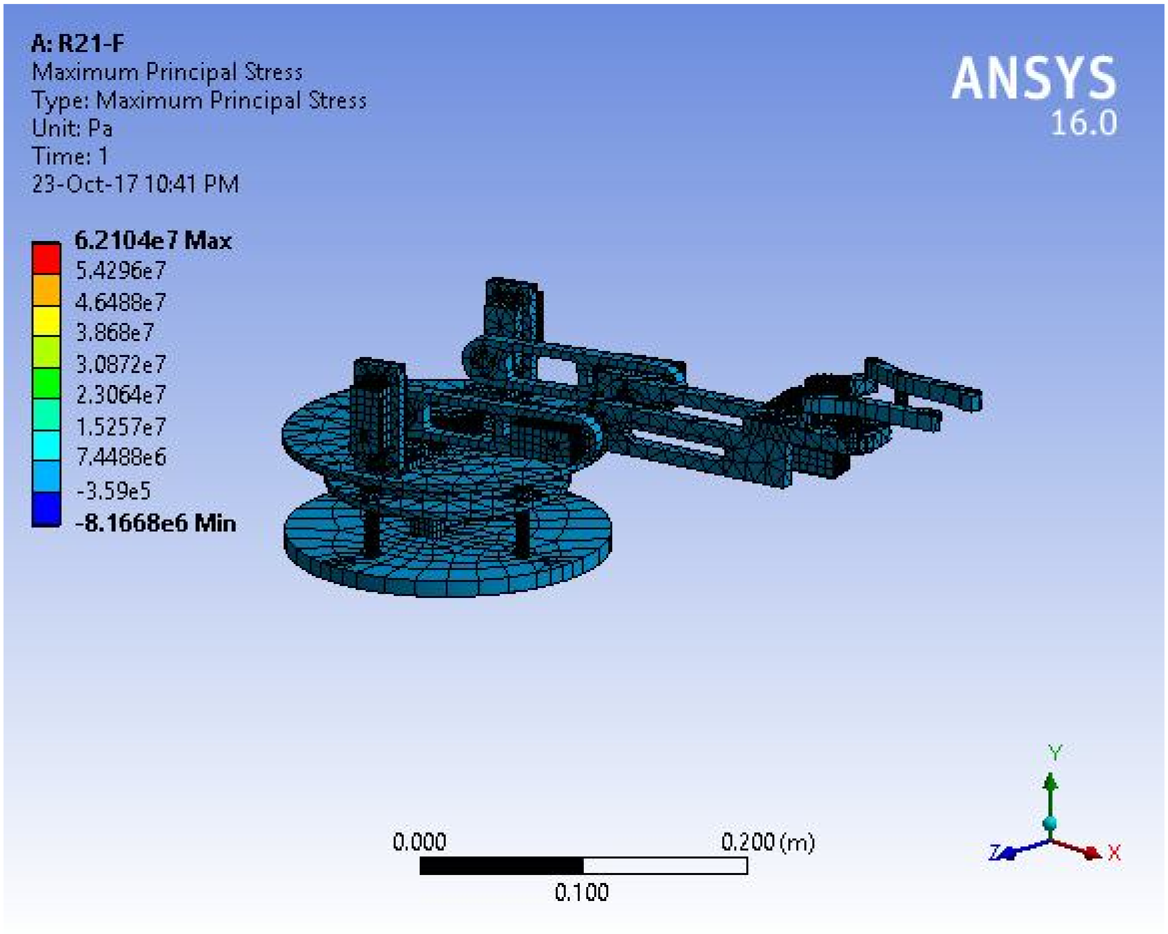

Figure 4.3 Maximum principle stress

The maximum stress pointed on the shoulder. And it decreases toward the gripper.Because the centre of rotation at the shoulder.

4.2.3 minimum principle stress

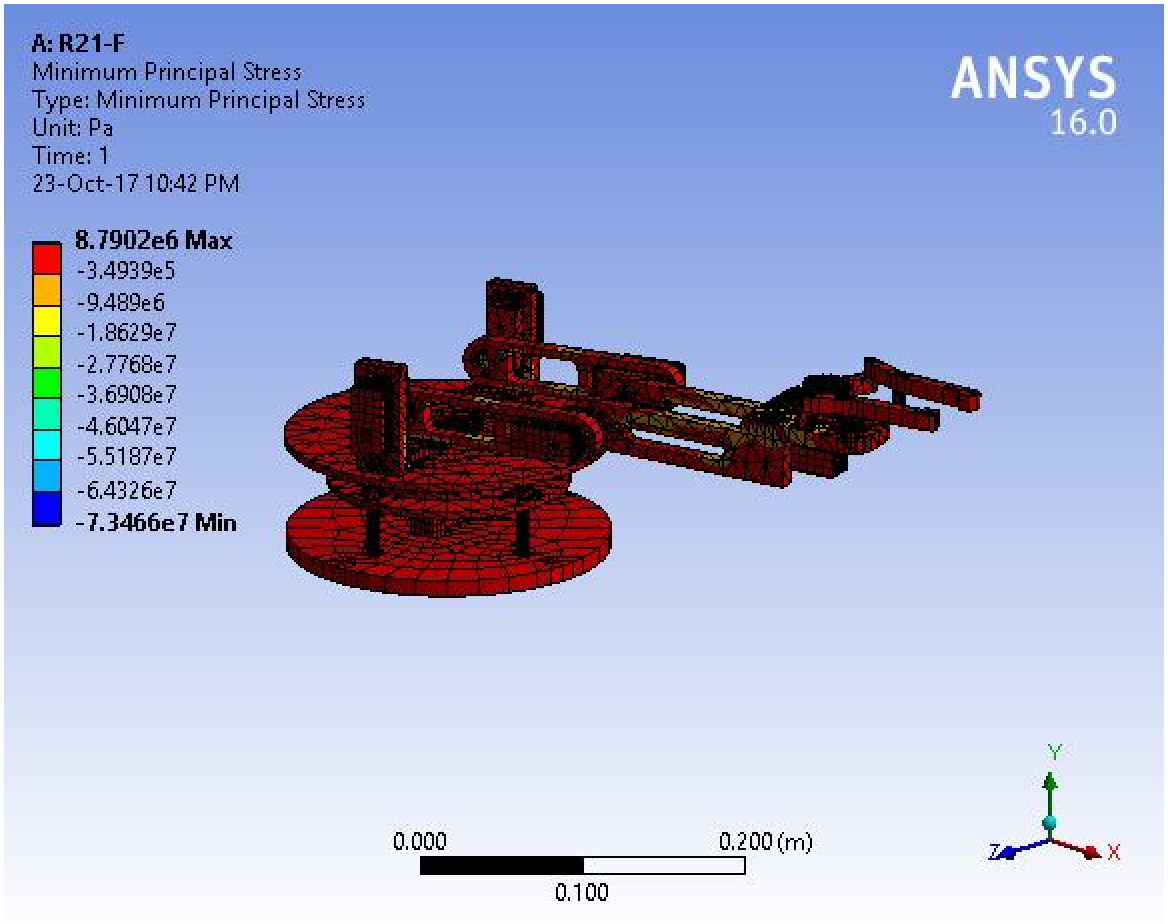

Figure 4.4 Minimum principle stress

The minimum stress pointed on the gripper. And it increases toward the shoulder.

4.2.4 Maximum principle Elastic Strain

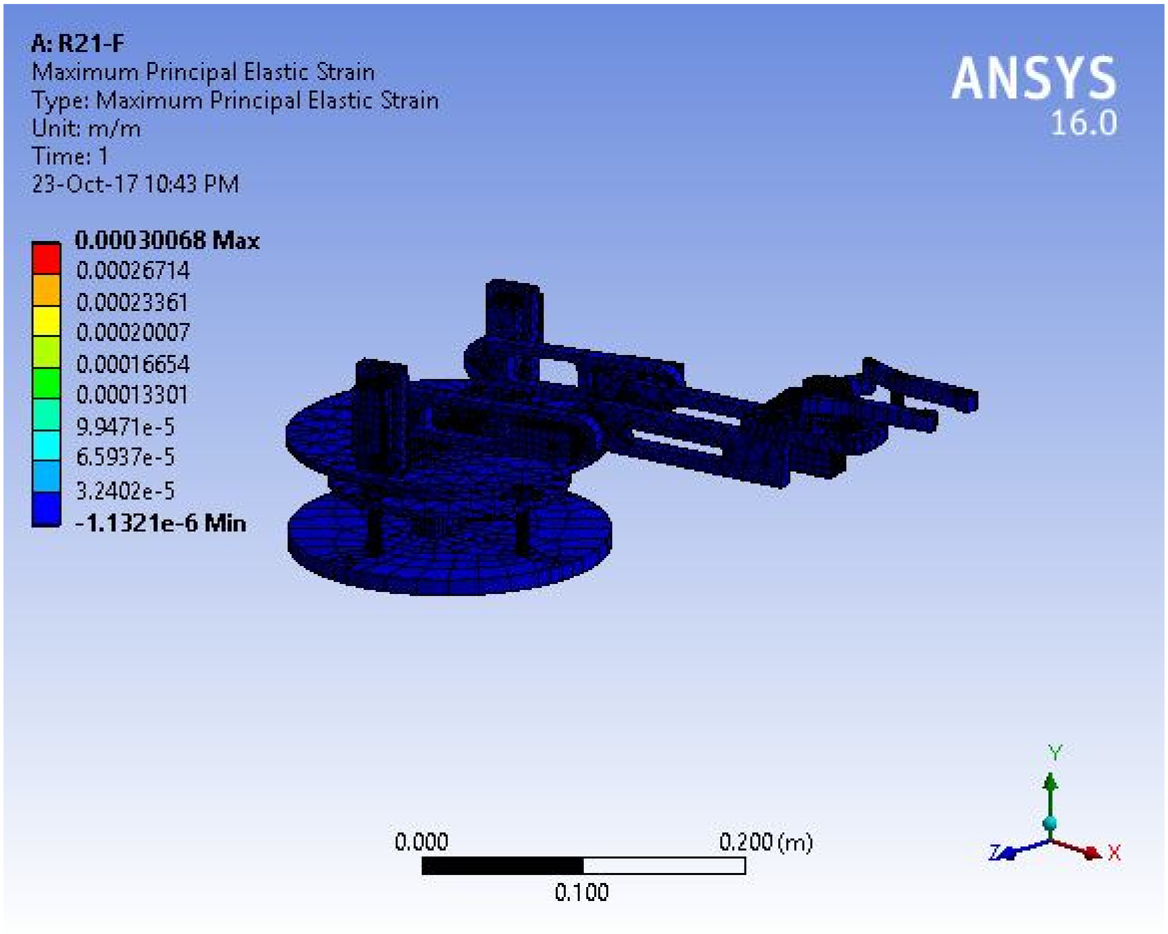

Figure 4.5 Maximum principle elastic strain

The maximum strain pointed on the shoulder. And it decreases toward the gripper. Because the centre of rotation at the shoulder.

4.2.5 Minimum principle Elastic Strain

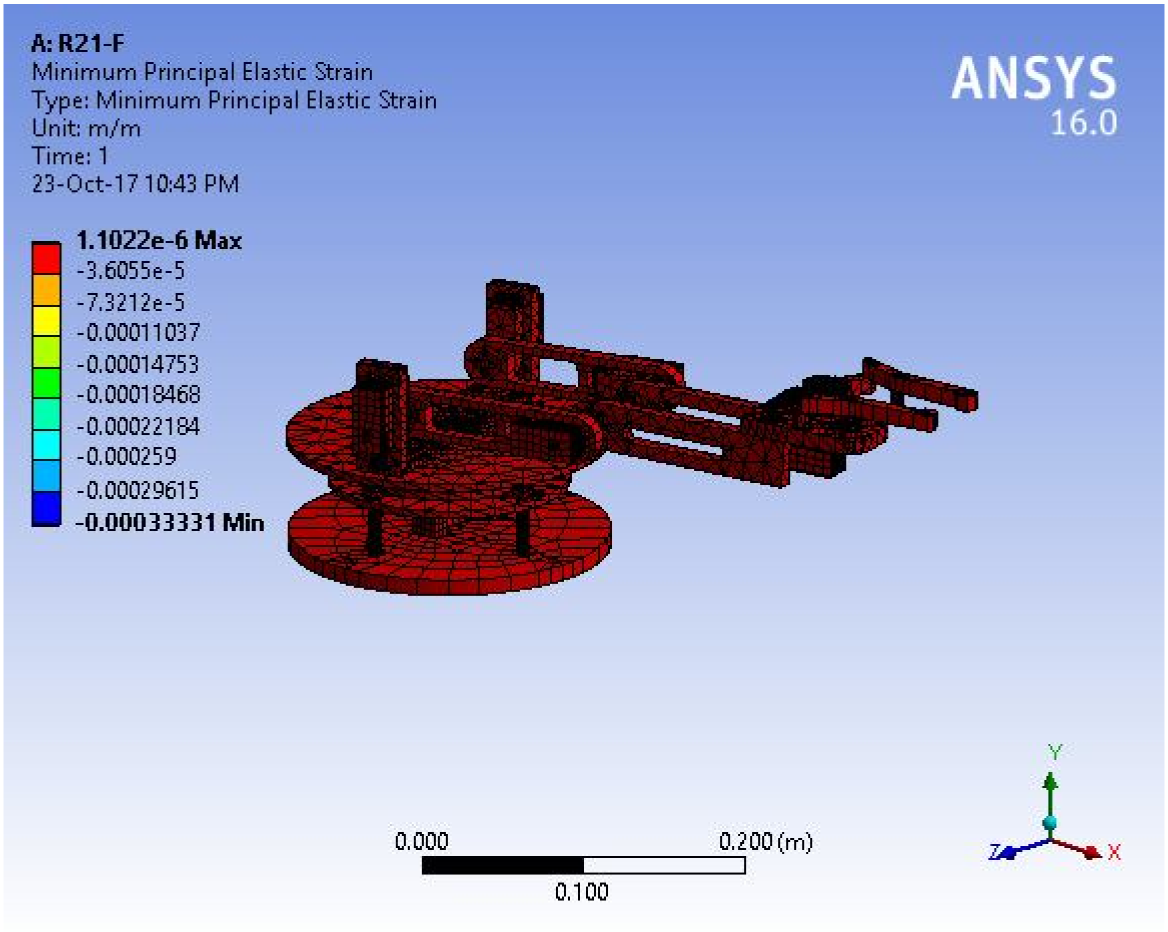

Figure 4.6 Minimum principle elastic strain

The maximum strain pointed on the shoulder. And it decreases toward the gripper.

4.3 Discussion

After applying the CAD-CAM processes, controlling system, as a result of the project the robot arm designed and manufactured to pick up and handle the load of 2Kg in 0.5 m^2 workspace. but the manufactured to pick up and handle the load of 2Kg in 0.5m^2 Workspace. But the available servo motors don't meet the specifications of torque (base & shoulder motors). Also the available regulators output current under required. The servo motors needed is 0.9 ampere (A) to use the maximum torque, but the available regulator Output is only 0.5 ampere. The motion of the system is divided to arms motion and gripper motion because of the above reasons.

CHAPTER FIVE

CONCLOUSION AND RECOMMENDATION

CHAPTER FIVE

CONCLOUSION AND RECOMMENDATION

5.1 conclusion

As a result of this project the robot arm will be of great use to perform repetitive tasks of picking and placing of small parts (up to 2Kg) in $0.5\ m^2$ workspace area as an educational robot in CNCLap at Sudan University of science and technology.

5.2 Recommendations

As the future work of the developed robotic arm, a natural network-controlled robot can be considered where the user can simply control the robot by giving algorithms commands or machine learning.

We recommend:

Build a slide linear motion for the arm base with preferred transition technique.

APPENDIX

Properties of Perspex

Mechanical Properties	Value	Parameter	Norm	Comments
Modulus of elasticity (Tensile strength) (MPa)	2400	1mm/min	DIN EN ISO 527-2	
Tensile Strength (MPa)	74	50mm/min	DIN EN ISO 527-2	
Tensile Strength at Yield (MPa)	74	50mm/min	DIN EN ISO 527-2	
Elongation at Yield (%)	6	50mm-min	DIN EN ISO 527-2	
Elongation at break (%)	49	50mm/min	DIN EN ISO 527-2	
Modulus of elasticity (Flexural test)	2400	2mm/min, 10N	DIN EN ISO 178	
Compression Strength (MPa)	21	1% / 2%, 5mm/min, 10N	EN ISO 604	
Impact strength (Charpy) (KJ/m^2)	n.b.	max 7,5J	DIN EN ISO 179-1eU	
Notched impact strength (Charpy) (KJ/m^2)	9	max 7,5J	DIN EN ISO 179-1eU	
Ball indentation hardness (MPa)	75	-	ISO 2039-1	

REFERENCES

[1] A.Elfasakhany, ″Design and Development of a competitive Low-cost Robot Arm with four degree of freedom, Mod. Mech. Eng. Vol. 1 no. 2, pp. 47-55, 2011.

[2] High Torque MG996R specification sheet.

[3] Arduino, ″Arduino Mega 2560.

http://arduino.cc/en/Main/arduinoBoardMega2560, p. 2560, 2014.

[4] Industrial Robot, By international federation of robotics (IFR).

[5] Kinematic analysis for Robot Arm, by Prof. COŞKUN YETIM.